Comments on "Draft Guidance For Evaluating The Vapor Intrusion to Indoor Air Pathway From Groundwater and Soils (Subsurface Vapor Intrusion Guidance)"

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Submitted by:
CE Schmidt, Ph.D.
19200 Live Oak Road
Red Bluff, CA 96080
(530) 529-4256
Fax- 529-4878
Email: schmidtce@aol.com
Website: ceschmidt.com

Submitted to:
EPA's Electronic Public Docket (http://www.epa.gov/edocket)
Email to Henry Schuver (schuver.henry@epa.gov)

INTRODUCTION

The following comments on the ***"Draft Guidance For Evaluating The Vapor Intrusion to Indoor Air Pathway From Groundwater and Soil (Subsurface Vapor Intrusion Guidance-*** Draft Guidance), Document ID RCRA-2002-0033-0001 are submitted to the Federal Register Notice of November 29, 2002.

The Draft Guidance document provides users' with a tool for conducting screening evaluations as to whether or not the air pathway for subsurface vapor intrusion exposure pathway is complete and occupants or residents are potentially exposed to contaminants via infiltration into structures and contamination of indoor air. A three tiered approach including *Primary Screening* (Tier 1), *Secondary Screening* (Tier 2), and *Site-Specific Screening* (Tier 3) is provided that relies on representative site characterization data (soil, groundwater, soil gas concentration data, distance to contamination, and site geology information, etc) and heuristic, predictive modeling to estimate potential exposure from a known subsurface contamination source. The Johnson and Ettinger Model (J&M) is the predictive model used, which has been shown to be conservative screening tool, if used properly, to represent indoor exposure.[1] If site characterization and descriptive data are used properly in the predictive screening tool and the result of the analysis shows that the vapor intrusion pathway is "incomplete", the general consensus is that occupants or residents are not at risk and the exposure potential issue is adequately addressed and dismissed. But if the site is considered by screening to have a "complete" vapor intrusion pathway, then further consideration of the current site situation is recommended. The guidance offers a progression of more complex or more in-depth assessment recommendations that hopefully result in an adequate characterization of potential health risk for occupants/residents in the subject structure.

The focus of these comments is related to those recommendations for sites that have demonstrated a potential vapor intrusion pathway; those sites that have predicted endpoint indoor air concentrations that exceed guidance criteria for acceptable health risk based on inhalation of indoor affected by vapor intrusion. Insufficient technical guidance has been provided to assist the user in conducting direct measurement of exposure potential in support of an adequate health risk assessment needed to establish an incremental health risk to occupants/residents where screening criteria are exceeded.

EVALUATION PROCESS RECOMMENDED IN GUIDANCE

The multi-tiered guidance describes a logical progression of site investigation activities that culminate in Tier 3- Site Specific Pathway Assessments (summarized in Figure13 and described on pages 38-50). The guidance relies conceptually on the protocol provided in the USEPA Air/Superfund National Technical Guidance Study Series, specifically Volume 2, whose intent was to provide site managers with the technical guidance for conducting an assessment of the air pathway (air pathway assessment-APA) and developing input for health risk assessment.[2, 3] The focus is on using applicable technologies, both predictive and measured, in order to assess the migration of contaminants from sources to receptors.

Four recommendations are provided for those Tier 3 sites where a complete vapor intrusion pathway is detected, including:

1) Direct measurement of foundation air concentrations before any indoor air measurements;
2) Direct measurement of indoor air concentrations coupled with home survey and sampling to identify background sources of vapor in ambient (outdoor) and/indoor air;
3) Removal of all indoor air sources before sampling indoors; and
4) Complementary site-specific mathematical modeling as appropriate.

Further discussions suggest that additional soil gas testing (e.g. sub slab or crawl space) and mathematical modeling (similar to Tier 2 activities) are recommended given the complexities of direct measurement approaches. Air monitoring of indoor and outdoor air is suggested if the building is accessible and other “more direct measures of potential impact, such as emission flux chambers or soil gas surveys” are recommended for sites, especially if the building is not accessible or doesn’t exist (future building scenario), that indicate unacceptable inhalation risk from Tier 1, 2, and 3 screening activities.

Once a potential inhalation risk is identified using appropriate screening level technologies, the most commonly used being soil gas testing and predictive modeling using either the Guidance Document look-up tables or site-specific screening modeling (J&E), there are two direct measurement technologies or assessment approaches that are generally available and applicable that can be used to adequately assess actual, measured exposure to occupants to existing structures, namely: 1) indoor/outdoor ambient air monitoring, and 2) direct measurement of flux from the subsurface both on open soil over the plume and near the structure and, if possible, direct measurement of flux through the slab or sub floor. For the future building scenario site, the single option is direct measurement of flux over the impacted area.

Ambient Air Monitoring

Air monitoring of indoor and outdoor air requires knowledge of sample collection and selection of proper analytical techniques. There are many useful guidance documents available to assist in the direct measurement of indoor/outdoor air.[4, 5, 6] The components of a useful and practical air monitoring program include the selection of proper sample collection and analytical techniques(e.g., USEPA Method TO-14/TO-15 evacuated canisters collected as integrated ambient air samples over 8-to-24 hour time periods and analyzed by selective ion mode GC/MS for sub-ppbv method detection limits of site-specific VOCs), adequate project quality assurance protocols, and a technical approach designed to meet the specific needs and sample collection requirements of the subject site. Basically, ambient air samples are collected as integrated samples in multiple, first floor (or basement) rooms of the study structure, typically at 5-feet above the ground, at multiple locations, and on multiple days. This is required because ambient air data are antidotal and a significant range of ambient air concentration difference is expected as related to structure use and ventilation, assuming a fixed infiltration source. Representative outdoor air is concurrently sampled, along with the collection of site specific or regional ambient air data. Indoor room surveys are also conducted documenting materials or products that may be sources of VOCs beyond typical construction materials or furnishings, and ventilation system operations are documented. In some instances, it may be required to conduct control structure air monitoring (e.g., similar structure but not affected by the subsurface contamination). The complications of VOCs found in outdoor air, and from indoor sources that may range from industrial or manufacturing process or off gassing from materials or furnishings can be handled by studying those compounds as related to the subsurface source individually or as a ratio of study compounds (e.g., fingerprint approach). Even so, studying exposure by using indoor/outdoor air monitoring technologies is not necessarily straightforward. It is, however, an acceptable ‘next step’ when continued soil gas data (outside soil gas and sub slab soil gas) testing and mathematical models continue to show an unacceptable health risk. If designed and conducted properly, even in the absence of the ‘removal of all indoor air source before sampling occurs’, is a viable approach to reaching conclusions regarding unacceptable vapor intrusion.

Note that most structures over subsurface sources have some measurable vapor intrusion through slab seams and cracks, and vapors have also been reported migrating through sub flooring even with ventilated crawl spaces (e.g., pier and post construction). However, the goal is to accurately assess the level of infiltration and thus the resulting endpoint ambient air (indoor) concentration. As such, a source assessment approach is desirable.

Direct Measurement of Area Source Flux

The other direct measurement approach referenced in the Guidance Document as a Tier 3 approach is flux chambers. The USEPA has provided a Surface Isolation Flux Chamber Guidance Document that describes the construction and use of a dynamic flux chamber that has application as a ‘source assessment’ technology for studying vapor intrusion into structures[7]. The technology is described as an ‘in-depth’ assessment technology in the Technical Guidance

Series Volume 2 and other guidance documents for collecting direct measured flux data from area sources.[2, 3] The technology provides for the collection of volatile and semi-volatile compound flux from solid, sludge, and liquid surfaces at atmospheric pressure conditions and has been reported as an effective technology for generating data of known accuracy and precision from area sources.[8-14] Initial applications of the technology focused on RCRA treatment, storage and disposal air pathway analysis and CERCLA uncontrolled waste site RI/FS project support including controlling (engineering analysis) and predicting off-site impacts from site activities such as excavation and in-situ or on-site waste treatment.[15, 16, 17] Other early applications included assessing the nature and extent of air pathway concerns related to the petroleum industry[18,19] as well as chemical wastewater treatment facilties[20] and municipal wastewater treatment facilities including odor emissions.[21,22,23] The technology has been widely used for assisting in site assessment programs that required an investigation of the air pathway for future land redevelopment[24, 25,26] and numerous other applications including land treatment, landfill disposal, agricultural, and industrial applications are documented.[27] However, the first application for assessing infiltration through seam and cracks came with the need to assess petroleum emissions through cement slab seams in an oil/water separator unit at a petroleum refinery.[28] Assessing impact on open soil over groundwater plumes, for instance, was a straightforward application of the technology[29, 30] however, the combination of outdoor, open soil flux testing over a known subsurface source (typically a dissolved-phase groundwater plume) with infiltration through a slab provided for adequate assessment of the vapor infiltration into structures.[31-36] Testing at sites where predictive modeling was conducted as described using proper site characterization data showed the conservative nature of the J&E model and use of the screening tool as a conservative estimate of potential exposure.[37, 38, 39] As such, the 'second step' using direct measured flux data, provides for the assessment of vapor infiltration.

Air Pathway Analysis Using Predictive Modeling, the USEPA Flux Chamber and Ambient Air Monitoring

For most sites, the second step after predictive modeling has indicated that the potential for vapor infiltration exists involves a combination of both recommended direct measurement technologies: flux chamber assessment using the USEPA recommended flux chamber, and ambient air monitoring indoor and outdoor ambient air. The concept is to study the source of potential exposure, the pathway of vapor intrusion, and the affect of vapor infiltration into the subject structure. A balanced air pathway analysis might include an adequate assessment of open soil, outdoor flux testing over the known subsurface source and near/around the structure foundation. This data set (open soil, outdoor flux) is intended to define the extent of impact at the surface, typical and maximum flux potential to the structure slab or sub-floor, and the full range of chemical species that is probably involved in the infiltration into the structure. An estimate of potential indoor infiltration can be obtained by using the outdoor flux data and an assumed infiltration or crack fraction to estimate indoor, endpoint concentration. The conservative ASTM crack fraction is 1% of the slab surface area, but other estimates based on civil engineering analysis reported in the literature is 0.056%.[40] As such, this activity provides for a source assessment of the area source as well as an estimate of potential infiltration and indoor exposure. It is important to note that for most studies, background flux in the urban environment is significant and background flux data should be collected representative of the local air shed but not related to the subsurface contamination on the study site. Measurable levels of ubiquitous volatile organic compounds are routinely measured at the sub-ppbv level in the flux chamber (above method and system blank levels) that background levels need to be considered when assigning surface flux to a known subsurface source.[41] This is especially important for a common air contaminant such as benzene and other components found in petroleum fuels, urban air, and in contaminated groundwater from surface and subsurface releases to the environment.

Indoor infiltration testing using the flux chamber typically involves testing on uncovered cement slab or sub-flooring at likely points of infiltration. Both uncracked or continuous slab and seamed/cracked slab are tested. Screening is typically performed using a field portable instrument or an onsite laboratory capability and locations for flux chamber testing are selected and tested. The flux chamber sealing on the hard slab is recommended and adequate testing is required to assess mass transfer from seams and cracks in the slab. If uncovered slab surfaces are not available, testing is typically conducted on sidewalks or patios around the structure. Data are generated as mass emitted per linear feet of seam/crack, prorated to the footprint of the surface area of the slab that is affected, and infiltration flux calculated is input into a ventilation calculation resulting in an endpoint exposure concentration (indoor) for health risk assessment. These data provide a second and more representative estimate of exposure potential and represent the "pathway" of migration as opposed to the "source" of infiltration as represented by the outdoor, open soil flux. Note that the USEPA flux chamber measures flux at the ambient pressure the measurement is performed (vented chamber). As such, the building pressure, negative or positive in comparison to outdoor ambient pressure is conveyed in the measurement. Most structures are at positive or ambient pressure, however, this variable is accounted for in the proper use of the USEPA recommended flux chamber design and operation. Data can be colleted at induced pressures (e.g., -4Pa) if indoor underpressurization or negative pressure compared to ambient pressure affecting infiltration flux is a project concern.[42]

The third component of the air pathway analysis assessing vapor infiltration is a limited amount of indoor and outdoor ambient air testing. These data, though not intended to serve as input to a health risk assessment, can be used to verify the results of the open soil outdoor flux testing and indoor infiltration flux assessment of indoor exposure. The concern is that significant points of infiltration into the structure might be overlooked in the indoor infiltration survey resulting in a low estimate of infiltration. A screening-level data set of indoor/outdoor air, typically collected during the direct flux chamber assessment, provides for a verification of testing protocol and endpoint comparison data (calculated endpoint indoor concentration versus screening-level measured ambient indoor concentration).

Summary

The Draft Guidance provides for an air pathway analysis approach applied to the unique exposure scenario of infiltration of vapors from subsurface sources. The Guidance, however, does not provide adequate direction for those sites that demonstrate an exceedence of health criteria or have the potential for exposure to occupants/residents via infiltration into structures. Comments have been provided that include a discussion of technically sound and referenced testing methodology that are reported to generate representative, 'in-depth' level site assessment data that can be used as input to health risk assessment. An air pathway analysis, consisting of predictive modeling using site specific data and robust ambient air monitoring, or predictive modeling using site specific data and outdoor and indoor flux chamber testing using the USEPA surface emission isolation flux chamber coupled with screening-level indoor and outdoor ambient air monitoring, constitute viable approaches for assessing the exposure potential of vapor infiltration from subsurface sources.

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